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Toward participatory decision-making in river corridor management: two case studies from the European Alps

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River managers are aware that river restoration entails addressing and effectively solving wicked social-ecological problems. Contemporary river corridor management is characterized by a variety of actors with different perspectives and interests, and by complex institutional settings and legal landscapes. Additionally, at the intersection between litho-, hydro-, and biological fields, new research suggests that river restoration should reactivate matter and energy fluxes, re-establish spatial connections with the floodplains, and enhance aquatic and terrestrial habitats without exacerbating flood risk. First, we outline a general structure of participatory river corridor management that addresses the following key requirements: (1) unambiguous, participatory spatial delineation of the river corridor; (2) comprehensive assessment of the river corridor's hydro-geomorphological, ecological, socio-economic and cultural processes; (3) transparency and consistency of the decision-making process; as well as (4) a coherent envisioning process. Subsequently, we present an overview of two river corridor management processes, conducted in South Tyrol, Italy. Specifically, we analysed the Etsch/Adige River corridor between Laas/Lasa and Glurns/Glorenza in the Upper Vinschgau/Venosta valley characterized by intense agricultural land use and the densely populated Eisack/Isarco River corridor in Brixen/Bressanone. Based on structured interviews with project managers, we highlight strengths and shortcomings of the proposed participatory management and envisage procedural improvements.

Keywords: river corridor management; participatory process; sustainability

1. Introduction

Healthy river corridors provide important ecosystem functions and generate the associated flows of ecosystem services for a large portion of the human population (Garcia and Pargement 2015). However, most rivers are highly human-modified or are being degraded at an increasing pace (Comiti 2012; Fryirs 2017), and their effective restoration and management, which is often difficult to achieve, requires a broad inter-disciplinary understanding of the system (Habersack and Piégay 2008; Gurnell *et al.* 2015; Brierley and Fryirs 2016). For example, acknowledging the numerous (physical,

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biological, ecological, economic, and social) dimensions of the river corridor system is essential to managing its complexity, rather than eliminating complexity from the system (Connick and Innes 2003). To address such a conundrum, cross-sectoral cooperation, stakeholder engagement, and procedural coherency are tools within a broader framework of collaborative adaptive management to enhance the river corridor management process (Bisjak *et al.* 2014a, 2014b).

Exposure to flood hazards has increased steadily over recent decades, and with it flood risk, resulting in serious loss of economic value and human lives. More than ever, effective river corridor management is needed to prevent further losses. 'Being prepared for the unexpected' turns out to be a major challenge for river managers confronted with complex flood risk mitigation problems in densely inhabited river corridors. This echoes precautionary views emerging from other management domains where 'tipping' (threshold-based) patterns have led to serious ecological and economic consequences (Brander, Brouwer, and Wagtendonk 2013; Kunreuther *et al.* 2014; McPhearson *et al.* 2015). Flood protection against unexpected and rare outcomes is often hindered due to a lack of preserved natural buffering capacities and attenuation of flood peaks, particularly in human-dominated (e.g. urban and agricultural) areas (Merz *et al.* 2010). The possibilities of smoothing peak flood intensities in space and time are limited, especially where major water storage within the river corridor is both technically and economically unfeasible. However, poor underlying management approaches that fail to incorporate a holistic perspective of the river corridor system also contribute to these outcomes.

River corridor management can be hindered at many stages of the visioning and rehabilitation process, leading to severe consequences for humans and the environment. For example, river management can have key problems, such as unwillingness of managers to share power, unresolved conflicts, and a lack of community capacity to anticipate, cope with, resist, and recover from perturbations (Monroe, Plate, and Oxarart 2013; Birkmann *et al.* 2013; Carr 2015). Other shortcomings affecting river rehabilitation projects include: (1) lack of clear statements regarding the intent, aims and vision of envisaged projects; (2) poor monitoring records and documentation of the effectiveness of management options; and (3) inappropriate collection, processing and archiving procedures, which ultimately concur to diminish the accuracy of post-project appraisals (Brierley *et al.* 2010).

In the context of water resources, river basin and river corridor management, integrated and participatory planning process schemes have been proposed and applied to overcome the abovementioned set of problems. Despite these considerable efforts and encouraging results, however, river corridor management is still a challenging endeavour. This is partially due to the fact that the spatial planning units, which are normally taken as reference in both regional and local planning efforts, may be in contrast with the river corridor as a hydro-morphologic spatial continuum (Rinaldi *et al.* 2016). Moreover, the traditionally applied planning solutions often reflect sectoral approaches and mono-disciplinary foci and may not mirror the developmental perspectives and the associated sustainability issues. We contend that these complex and interdisciplinary challenges are related to (1) process-related shortcomings that prevent a true engagement of stakeholders throughout the process; (2) river corridor related knowledge gaps (i.e. poor understanding of spatio-temporal definitions and system dynamics); and (3) inadequacies with respect to the representation of river corridor developmental vision ('Leitbild'), and measurable objectives to accurately assess the proposed management alternatives.

To address these fundamental issues, in Section 2 we present a methodology for effective participatory river corridor management and discuss the related procedural aspects. In Section 3, we provide an overview of two river corridor management processes, conducted in the European Alps and, specifically in South Tyrol, Italy. The two considered riverine settings were, respectively, the Etsch/Adige River corridor between Laas/Lasa and Glurns/Glorenza in the Upper Vinschgau/Venosta valley and the Eisack/Isarco River Corridor in Brixen/Bressanone. Whereas the Etsch/Adige River corridor comprises mainly agricultural areas covered by apple plantations and two relatively small-sized urban centres, the Eisack/Isarco River Corridor is densely inhabited. Large portions of both river corridors are prone to flooding, and the associated risk is significant in both cases due to the high cost of economic, human, and environmental consequences of flooding. We analyse the performance of the management process with respect to the participatory decision-making process through structured interviews with project managers. In parallel, we highlight strengths and shortcomings of the proposed participatory management and envisage potential procedural improvements.

2. Proposed methodology for effective river corridor management

The main aim of the European Water Framework Directive (WFD, issued in 2000) is to improve water resources management prioritizing sustainability and high protection for aquatic ecosystems (Ruiz-Villaverde and García-Rubio 2015). The key strategic element is the creation of space for public participation (PP), which should permeate ongoing planning and decision-making processes (Carr 2015). But, how can such an ambitious goal of a participatory management process be attained in river corridor management? As a matter of fact, according to a synthesis of US river restoration efforts by Bernhardt *et al*. (2005), neither the quality of the planning processes nor the intensity of PP assures sustainable interventions within the river corridor. With respect to the quality of the planning and decision-making process, Bernhardt *et al.* (2005) highlight that 20% of executed projects had no listed goals and that, in many cases, the planning and design details did not indicate whether projects were undertaken to restore stream systems or were merely river manipulation projects (e.g. bank stabilizations). Mazzorana *et al.* (2014) draw similar conclusions for projects implemented during the last century for rehabilitating mountain river segments in the European Alps. To avoid this frequent mismatch between supposed purposefulness and practical implementation effects, Palmer *et al.* (2005) suggest standards for ecologically successful river restoration. Among these standards, we highlight in particular the importance of defining a clear guiding image, of attaining measurable ecological improvements and of promoting resilience to external perturbations. The authors suggest that these standards, if adequately considered throughout the planning process, can contribute to ultimately establishing healthier and more self-sustaining river systems. Carr (2015) further outlines how participation is expected to enhance the management process, the quality of the decisions, and the reliability of implementation. Specifically, a participatory process: (1) provides space for deliberation and consensus building; (2) mobilizes and develops human and social capital; and (3) raises the legitimacy of the decisions.

However, despite these benefits of well-planned public engagement, making legitimate decisions based on cooperative PP does not necessarily assure the anticipated, desired and sustainable management outcomes. It is important to consider the decision space throughout the full management process. Based on the outlined requirements, the river corridor management approach presented here seeks to delimit the decision space in terms of intersections between the following dimensions that are important throughout

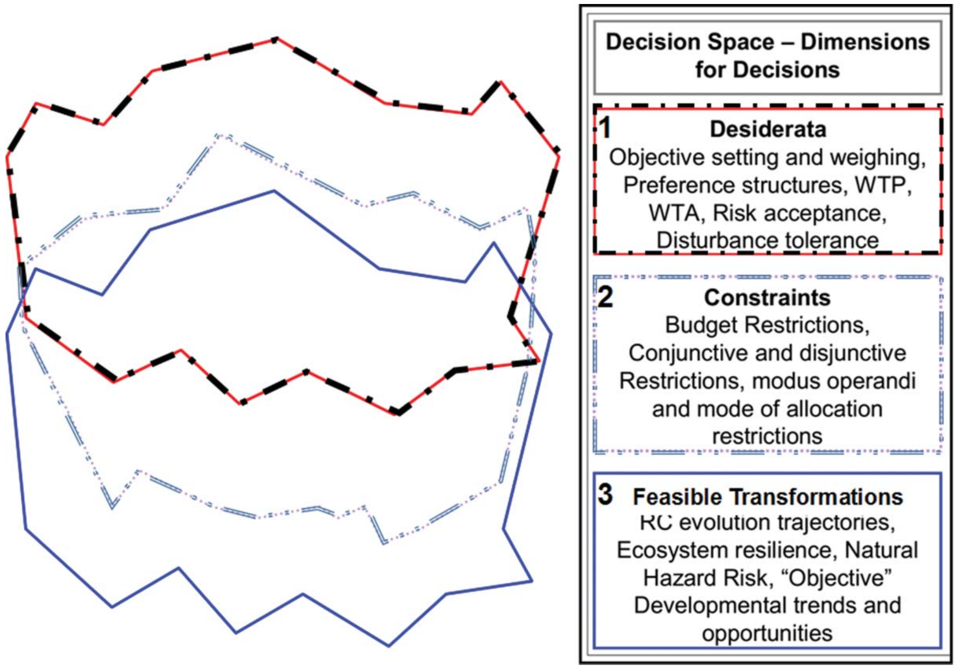

Figure 1. The decision space of participatory river corridor management.

the management and decision process (Figure 1): (1) *societal values*; (2) *legal and economic constraints*; and (3) *bio-physical possibilities.*

With respect to *societal values*, making the *desiderata* of society/stakeholders (or, alternatively, of a smaller representative steering panel) explicit is the first milestone of the proposed holistic river corridor management approach. Societal values, in this instance, refer to the values and preferences of the concerned citizens, their Willingness To Pay for risk (flooding) mitigation, and their Willingness To Accept risk (Baranzini and Ferro Luzzi 2001; Corso, Hammitt, and Graham 2001). Stakeholder engagement is a precondition for solving complex problems, such as flood risk management and managing urban riverscapes (Thaler and Levin-Keitel 2016). Stakeholder contributions, along with broad interdisciplinary scientific input, can improve understanding across formal and informal knowledge bases and glue together data and theories originating from different disciplines (Leniak *et al.* 2013; Stauffacher *et al.* 2008).

With respect to *the constraints* (e.g. legislative landscape, funding opportunities, etc.), the legislative landscape can be complex with multiple, sometimes competing, requirements. For example, legislative measures often require the scrupulous assessment of the biophysical river condition and the associated hydromorphological classifications (e.g. Rinaldi *et al.* 2013; Fryirs and Brierley 2016). For example, WFD established 'no further deterioration' and 'good ecological status' paradigms, while the later (2007) EU 'Floods' Directive requires reliable flood risk maps, flood risk management plans, and effective flood risk mitigation and adaptation strategies and measures. Still other legislative requirements may focus on the sufficient availability of good quality water for people's needs, the economy and the environment. Competing legislative requirements can further compound resource constraints faced by many projects, such as funding, time, and technical expertise (compare Krueger *et al.* 2012 for an extensive discussion of the role of expert knowledge in environmental modelling). The available funding opportunities may, if limited or initially insufficient, undermine the most urgently needed project initiatives. On the other hand, available funding can stimulate the pursuit of substitutive endeavours that may only marginally contribute to achieving the desired system changes (e.g. small scale palliative interventions which fail to establish the necessary bio-physical conditions to reactivate the river's ecosystem functions). These legislative and resource constraints highlight the importance of assuring that diverse, qualified participants actively contribute to the decision-making process by identifying the legal corridors and activating public and private funding channels (Bernhardt *et al.* 2005).

Finally, *the bio-physical system changes* can be achieved through a trans-disciplinary approach, integrating river corridor environmental-hydro-geo-morphological sciences (Bertoldi 2012), socio-economic sciences (Leniak *et al.* 2013), and non-academic partners in the knowledge generation process. For example, development possibilities are explored through a preliminary river corridor delimitation based on hydro-geo-morphological principles (e.g. Bravard and Petts 1996; Brierley and Fryirs 2005; The Nature Conservancy 2009).

Bio-physical changes may be limited by river corridor evolution trajectories, ecosystem resilience and natural hazard risk, ongoing developmental trends and economic contingencies (e.g. March, Therod, and Leenhardt 2012 with respect to water futures). However, the river condition can be characterized by identifying its reference river style (i.e. its potential hydro-morphologic setting compatible with water discharge and sediment transport regimes) with the associated patterns of evolution (Brierley and Fryirs 2009; Brierley *et al.* 2010). In this context, particular attention has to be devoted to the assessment of the current water discharge and sediment transport regimes. These may have been altered in the recent past (i.e. climate change, hydropower dams) and may, as a consequence, exert important controls with respect to the expected evolution patterns. In addition to the bio-physical and environmental contexts, the assessment of the feasible system changes must account for the social and economic possibilities that could be provided by river restoration. For example, establishing river corridors with significantly increased ecosystem services can have a net positive contribution to human well-being. Moreover, effectively succeeding in reversing river degradation may contribute to increased socio-ecological resilience to flooding (Nardini and Pavan 2012; Nardini, Meier, and Gomez Miguez 2015).

To attain, as mentioned at the beginning of this section and shown in Figure 1, an optimal synthesis between what society desires, what is allowed by the existing legal framework and is economically sustainable, and what complies with the natural evolution patterns (i.e. channel types/river styles), we contend that a participatory decision-making process is an essential requirement (see next subsection). Indeed, its absence may lead to a serious misalignment of these three essential requirements.

2.1. The participatory decision-making process

Throughout the river corridor management process, special attention to the participatory decision-making process is necessary to ensure buy-in and success of the endeavour (Connick and Innes 2003). Coinciding with Carr's recommendations for an enhanced river basin management (Carr 2015) we identify two basic tenets to be considered: (1) structured process and (2) consistency of the decision steps throughout the process.

Table 1. Clusters and associated sub-clusters of individuals who should be actively engaged in the river corridor management process.

Main clusters	Sub-clusters
1. Policy-Makers and Public Administrations with legal responsibilities in river corridors (management) at local, county/regional, and national levels	1.1. Governmental bodies: ministries, province/county/district/local offices
	1.2. Public agencies and management institutions for spatial planning, transport, nature, (drinking, and irrigation) water, floods, etc.
2. Process Shapers and Problem Solvers	2.1. Water Managers: Actors in charge to shape the river corridor management process and to create the collaborative environment for a multi-sectoral approach
	2.2. Process Facilitators: Key actors devoted to facilitate the collaborative process, to create space for negotiation and conflict resolution
	2.3. Advisors: Individuals with an innovative mindset for complex problem-solving
	2.4. Planners: Actors in charge to design the future river corridor
	2.5. Scientific members
3. Stakeholders (mostly private but some may be government-owned) with vested interests in the river corridor (land and/or river resource users)	3.1. Land owners, industry, agriculture, forestry, fisheries, recreation/tourism, gravel extraction sector, hydro-power sector, transport-navigation sector
	3.2. NGOs and Associations
4. Potentially Interested Public	4.1. Local Residents
	4.2. Schools, Universities

Every successful process with PP starts with preparation – from setting clear process goals, defining the area and scope of work, and identifying the core team and all the participants to be involved in the process (Table 1; Bisjak *et al.* 2014a).

Once the PP has successfully started, we suggest the following procedure as a practical way to support, monitor and rationalize it (see Figure 2). Based on the proposal by Nardini (2005), which originally featured six sequential procedural steps, our proposal presents seven steps with iterations and features a consistency matrix to account for its coherent application.

The procedural steps are:

(1) Diagnosis: diagnosis entails a refined scoping based on an integrated river corridor characterization (i.e. from geo-morphological, biotic, economic, and social perspectives) and other concurring processes affecting the river corridor. The results of the diagnosis will be used to clearly define and delimit the problems and opportunities. It is of paramount importance to understand the decision-making procedures, the consuetudinary management styles, and existing stakeholder relationships (Bisjak *et al.* 2014a; Muñoz-Erickson 2014).

(2) Vision and objectives: this step entails articulating a common vision and the associated operational target system with clearly identified and measurable

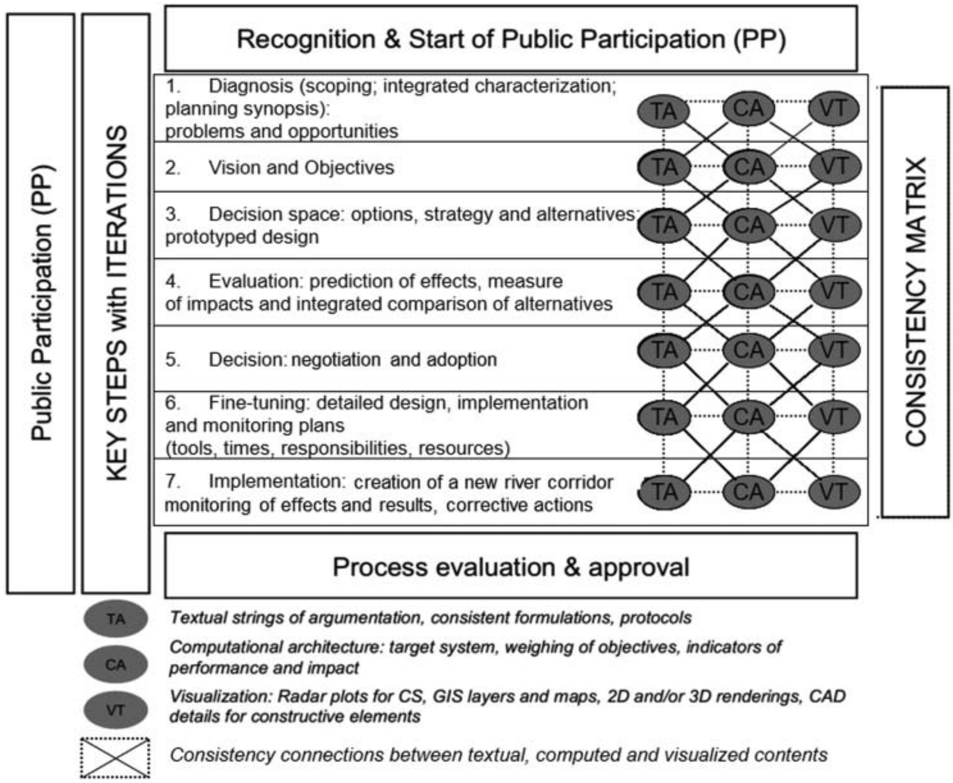

Figure 2. Proposed scheme of participatory decision-making process (modified based on Nardini 2005).

objectives (Wiek and Iwaniec 2013; Iwaniec *et al.* 2014). The formulated vision should describe a river corridor configuration as 'a model' to be approximated. Although this model can be revised during successive iterations of the procedure (Gurnell *et al.* 2016; Brierley and Fryirs 2016), it is intended as a set of specifications supporting design and decision-making (Withycombe Keeler *et al.* 2015; Schmitt Olabisi *et al*. 2010). It has to be remarked that the vision should be co-developed by the transdisciplinary team of stakeholders involved. The visioning should be an iterative process that changes with the changing needs of stakeholders and the changing ecological/hydrologic functioning of the river corridor. Moreover, a 'neutral' space for discussing and confronting contested issues should be provided before delving into the decision-making steps.

(3) Decision space: strategies, decision options, and management alternatives result from the specific constraints (e.g. resources and legislative restrictions) and development possibilities of each individual project (components B and C in Figure 1).

(4) Evaluation: in this step, the emerging potential solutions and trade-offs are evaluated based on well-known cost-benefit approaches (Kruschwitz 2008) or multi-attribute utility theory-based techniques (Eisenführ, Weber, and Langer 2010). Both the current and the envisioned river corridor performance should be evaluated as a key tool (1) to quantitatively and qualitatively assess the trade-offs

of potential decisions and outcomes, (2) to rapidly correct undesired evolution patterns, and (3) to communicate with the public about the results in an accountable form in order to revise strategies with changing values and goals.

(5) Decision: in this phase, the optimal solutions are adopted.

(6) Fine-tuning: in this step, the adopted solutions are refined through a detailed design. To reactivate the hydro-morphological and ecological system dynamics, while keeping the risk acceptable and reducing cost flows over the system's life-cycle to sustainable levels, fine-tuning entails an accurate determination of the construction types employed (i.e. green and grey infrastructures) and their dimensions according to the prescribed safety factors (Gulvanessian 2009) and to the required hydrodynamic functionalities (see Mazzorana *et al.* 2014; Mazzorana and Fuchs 2010). Operationally, an implementation plan can be used to define the necessary tools, time schedule, responsibilities, and resources.

(7) Supervised implementation: in this step, solutions are implemented according to the elaborated implementation plan and decisively contribute to create and shape the new river corridor. Following a previously elaborated monitoring plan, specific activities are carried out to gather relevant knowledge about ongoing system evolutions and to eventually detect and evaluate unforeseen system changes (compare also procedural Step 4) and intervene, if necessary, with corrective measures which result from a new process iteration (see Figure 2).

As mentioned, one essential innovative feature of the proposed procedure is the conception of a consistency matrix. The consistency matrix allows tracing all decision-relevant knowledge and information throughout the participatory decision-making process (see seven steps in Figure 2). This knowledge should be anchored in an ideal combination of (1) logically structured textual statements (i.e. internally consistent propositions related to the river corridor vision; definition of the goals and objectives); (2) quantified processes and evaluated system states (i.e. hazard intensities; river quality indicator values, hydromorphological indicator values); and (3) visualized scenarios (i.e. spatialized risk maps; maps showing the beneficial and adverse effects of management alternatives; rendered scenarios of future river corridor configurations). As represented in Figure 2, these three forms of knowledge representation complement each other and provide for each key step a consistent pool of textual strings of Argumentation (TA) and of quantified knowledge elements, which are processed through a suitable computational architecture (CA) and visualized through an appropriated set of visualization tools (VT, such as GIS, rendering instruments, sketches, etc.).

Formative scenario analysis methods support the corroboration of knowledge in the TA domain (Scholz and Tietje 2002; Tietje 2005; Mazzorana, Hübl, and Fuchs 2009). Following the topology proposed by Ducot and Lubben (1980), scenarios can be classified according to (1) their causality; (2) their normative or descriptive nature; and (3) their temporal and spatial dimensions.

To make quantified knowledge elements accessible for the decision-making process we suggest the conceptual scheme of a CA which adopts a compact set of key objectives (risks, disturbances, risks, costs, natural value, and externalities) to be used as a coherent target system in river corridor management. Details about the CA are provided in Appen dix 1 (online supplemental data).

Visualized information is an important knowledge element throughout all steps of the participatory decision-making process. Useful visualization principles and techniques (or

VT) have been proposed in the field of landscape design (Mertens 2009; Wang *et al.* 2005) and also as a valid support for participatory decision-making at a river corridor scale (see Revital 2014, for an extensive description of concepts and methods).

Consistency throughout the participatory decision-making process is of paramount importance (Figure 2). First, it has to be assured that the complementary and overlapping knowledge expressed in textual, numerical and visualized form is free of contradictions (i.e. flood hazard scenarios identified by (1) a clear textual description of the process dynamics; (2) by the associated quantifications in terms of local flow depths and velocities; and (3) by convenient visual representations in the form of hazard maps). Second, it is essential to identify relationships between the emerging problems, objectives, strategies and alternatives, and their technical evaluation, as well as the resulting design refinements. Third, the consistency matrix ensures that knowledge generated in a previous procedural step and formalized in a specific form (e.g. visualizations) is accessible to inform subsequent steps and knowledge generation.

2.2. From river corridor management to its governance

Let us imagine now that the whole process described above has been (successfully) carried out and that a river corridor has been established and is being managed for several years. Any time a new river basin project occurs, be it infrastructure (i.e. fundamental facilities such as a new road, an airport or flood protection measures such as levees and retention areas), or new management tools (i.e. agricultural incentives or rules), the question arises whether the project would contribute to the 'Leitbild' (i.e. defined vision) or if it rather negatively detracts from the shared vision. It is then essential to follow a clear and concerted procedure that supports the actors involved toward making a decision (Figure 3).

The procedure outlined in Figure 3 encompasses different steps: first (Block **A**), assesses whether the new project can be dealt with at the local level (left side) or not (right level). If the new project is at a larger (or different) corridor scale than the original scale of previous projects, the current river corridor must be re-evaluated. If the scale and scope are modified, a completely new participatory decision-making process (PP) has to be undertaken. If the new project does not impact on the larger river corridor, local analysis of the project is sufficient. The participatory decision-making process (Blocks **B**) has the same structure for any scale, adhering to the steps in Figure 2. In the local scale case, the process embeds an Environmental Impact Assessment (EIA) to examine project implementation outcomes and alternatives. When the project is implemented, a thorough in itinere and ex-post monitoring are carried out (Block **C**) with the aim of ascertaining whether the planned actions and stated objectives were achieved. The evaluation may feedback to earlier stages allowing interventions and management to address detected problems.

3. Performance analysis of recent river corridor management processes in South Tyrol, Italy

In order to demonstrate how the proposed participatory and management processes are applied, we conducted a performance analysis of the river corridor management processes in two case studies in South Tyrol, Italy: (1) River Corridor Plan Upper Vinschgau/Venosta valley, also called 'Etsch- Dialog'; (2) Isarco River Corridor Management at Brixen/Bressanone, also called 'StadtLandFluss'. The main focus of the

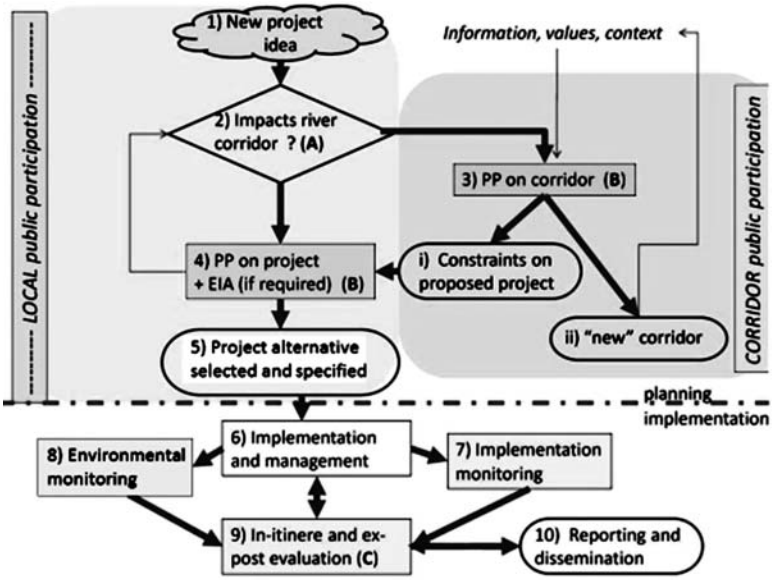

Figure 3. Scheme showing the process proposed to manage the occurrence of a new project (Nardini, Meier, and Gomez Miguez 2015). (A)–(C) represent the different blocks of the procedure proposed to manage the occurrence of a new project. The acronyms PP and EIA stand respectively for the public participation process and Environmental Impact Assessment.

performance analysis is explicitly on the participatory decision-making process (PP) (Figure 2 and Block **B** in Figure 4). In this section, we first provide essential background information relating to each river corridor case study. We then discuss the peculiar characteristics of the participatory decision-making process (key steps and challenges) that emerged from structured, in-person interviews (following methods from Bernard, Wutich, and Ryan 2017; Bernard 2011) conducted with project leaders (Section 3.2 for details). The project leaders are all experienced professionals in the river restoration sector (i.e. at least 10 years of river management after earning a master's degree in water management and affine studies) and employees of regional water management authorities. They were responsible for structuring and reliably coordinating all river corridor management activities throughout the project duration.

3.1. The river corridor management processes

3.1.1. River corridor plan Upper Vinschgau/Venosta (*'*Etsch-Dialog*'*)

This river corridor management project aimed to substantially contribute to a sustainable development of the Etsch/Adige River corridor between Laas/Lasa and Glurns/Glorenza in the Upper Vinschgau/Venosta valley. The defined river corridor area, including the Adige River floodplain, is about 36 km^2 and the considered Adige River length is approximately 14 km (Figure 4[a]). The elaboration of the river management lasted from 2008 to 2010 and since then a series of projects followed with the aim of implementing the conceived catalogue of measures (Figure 4[b], for details about the restoration measures at the Prader Sand and Figure 4[c] for a detailed view of the flood protection measures in Schluderns/Sluderno).

Figure 4. (a) Overview of the Adige River corridors, (b) details of the natural river area at the Prader Sand, (c) view of flood protection works in the city of Schluderns/Sluderno. Source: Autonomous Province of Bolzano/Bozen.

The overall project budget was rather large compared with other similar project initiatives (863,620 €); 63% was allocated to site-specific studies, 12.6% was devoted to project management activities, and 24.4% was invested to support the participatory process and involve the broader public sphere. Additional studies and activities were financed by the Departments of Nature Protection, the Adige River Basin Authority, the Agency for Water Protection, the hydropower company SEL-Edison, the reclamation consortium Vinschgau/Venosta, and the municipalities involved.

The project intersected different disciplinary foci (flood hazards, spatial planning and land use, hydropower production, agriculture, and ecology) and took into consideration a variety of interests from the actors involved. The actors involved in the PP (a total number of 14 individuals as permanent members of the steering committee and 45 individuals actively contributing to the river corridor forum) envisioned a river corridor where economic growth is compatible with a substantial enhancement of flood protection and with a parallel improvement in the ecological status. This process involved representation from almost all categories of actors defined in Table 1, although a stronger involvement of Process Shapers and Problem Solvers might have been desirable.

From a flood risk management perspective, a design flood with a return period of 30 years was defined for rural areas, and in urbanized areas this target was raised to a flood with a return period of 100 years. These goals are ambitions given that the river corridor is characterized by intense agricultural activities where water resources are depleted by both irrigation and hydropower production purposes. Nonetheless ecologically valuable riparian forest is still present in the floodplain and needs to be conserved. In addition, the urbanized area is characterized by compact villages mainly located on alluvial fans and debris cones.

After an in-depth analysis of the current state of the river corridor, the previously drafted vision was re-negotiated and approved by the steering committee with the consensus of a broader river panel (River Forum) without substantial modifications. Subsequently, a catalogue of management alternatives (focused on flood mitigation) was elaborated. Throughout these planning steps, tailored communication and dissemination activities were carried out, mainly led by a private PR-agency. These activities included action days in schools, sensitization activities located at the river, thematic presentations and excursions. Moreover, a project website provided updated information about the status of the implementation process. Project brochures and leaflets were distributed to raise awareness. As such the River Forum plays a supporting role, but in no way substitutes the official and binding procedures.

3.1.2. Eisack/Isarco rivercorridor management Brixen/Bressanone ('StadtLandFluss')

This river corridor management process (for the Eisack/Isarco River and Rienz/Rienza River) was launched within the European Regional Development Fund programme (EFRE). The project initiator was the Department of Hydraulic Engineering of the Autonomous Province of Bozen/Bolzano. The project was supported by the municipalities of Brixen/Bressanone and Vahrn/Varna. The declared aim of the actors involved in the PP (a total number of 16 individuals as permanent members of the steering committee and 36 individuals actively contributing in the river corridor forum) was the elaboration of sustainable flood protection concepts to mitigate hazards for the city of Brixen/Bressanone and other endangered settlements also addressing relevant ecological and environmental issues. The project area, mainly coinciding with the entire floodplain of the Eisack and Rienz in the surroundings of Brixen/Bressanone, is about 19 km^2. The project area is densely urbanized (approx. 24,000 inhabitants) and is also an important productive district in the region (Figure 5[a]–5[c]). The elaboration of the river management lasted from 2009 to 2011.

The overall project budget was 592,000 €, 93% of which was funded by the EFRE programme and the residual was funded by the municipalities of Brixen/Bressanone and Vahrn/Varna. From the overall budget 59% was devoted to specific studies, 14% to project management activities, and 27% was invested to support the participatory process and involve the broader public sphere. Concerning project organization, the project was strategically led by a steering group composed of two representatives of the Department of Hydraulic Engineering and two representatives of the municipalities of Brixen/Bressanone and Vahrn/Varna, respectively. For the project management-related tasks, an external project manager was contracted to strongly support the project and the Department of Hydraulic Engineering.

All specific studies (i.e. hydrology, hydraulics, water management, ecological and environmental assessments, land use, and spatial planning) as well as PR activities were conducted by contracted external experts. External experts provided significant inputs for the planning of provisional flood risk mitigation concepts and drafted a synthesis report. On this basis, a 'Leitbild' was defined on a textual level only. The involved actors envisioned a river flowing through the urban area of Bressanone/Brixen with low flood

Figure 5. (a) Overview of the river corridor at and downstream of the confluence of the Eisack and Rienz, (b) Eisack River segment at the upstream boundary of the project area, and (c) at the downstream boundary. Source: Autonomous Province of Bolzano/Bozen.

risk (i.e. no expected damage below a design event with a return period of 30 years). Along with this ambitious flood protection target, the objective was to enhance the ecological status of the river and its recreational value. The steering group identified a series of guiding principles and actions in order to achieve the outlined river vision. However, final consensus on the proposed solutions was not reached. In fact, an idea contest is now in progress with the ultimate aim to create a solid consensus on the vision and to identify feasible solutions. Similar to previously described river corridor management processes (Nikowitz and Ernst 2011), this consensus-based approach, which is not legally binding, does not substitute for the official decision-making procedures in which the municipal council has the power to make binding decisions.

3.2. Structured, in-person interviews with project leaders

As an employee of the Department of Hydraulic Engineering, the main driving force behind the abovementioned river corridor management initiatives, the lead author had the opportunity to observe from the progress of several analytic tasks (i.e. hydraulic studies, to the quality assessment of externally provided planning products), decision support activities (i.e. evaluation of project alternatives, preparation of decision-relevant stakeholder workshops, etc.), and the most relevant decision-making steps. This provided a unique opportunity not only to monitor from the inside the ongoing project dynamics, but also to build trust relationships with the key actors and project leaders involved. The detailed interviews with project leaders allowed us to examine, from their daily experiences, how the subtleties of the planning and decision-making process directly affected the overall project performance. Within the framework of the SEE-River project (Bisjak *et al.* 2014a, 2014b) we conducted structured interviews with a duration of approximately two hours with each main project leader from the two river corridor management case studies. The first two interviews were conducted by strictly following a prepared set of questions in a pre-defined order and the last meeting was devoted to specifically addressing important issues that emerged from the analysis of previous interviews. Specific sets of questions were formulated for defined key steps of the participatory decision-making process, namely (1) diagnosis; (2) vision and objectives for the river corridor; (3) decision space (options, strategies, alternatives); (4) evaluation of alternatives; (5) decision; and (6) specifying what? (Figure 2). The step (7) supervised implementation was analysed in detail since the initiation phase and implementation are yet to occur. The spirit of the structured set of questions was not to judge a project; rather, it aimed at being a support to the project development. In Appendix 2 (online supplemental data), we provide the full set of interview questions and the associated answers.

3.3. Insights

According to the proposed participatory process (Figure 2), we reviewed each case study's participatory process and conducted a performance analysis based on the conceptual scheme proposed by Klein and Scholl (2004). Following this scheme, we dissected the river corridor management process and assigned shortcomings (i.e. using 1 to 3 bullets as ranking tool) with respect to each step of the decision process (Figure 6).

With respect to the participatory decision-making process the following problems resulted from our analysis:

(a) Partial inability to create, from the early planning stages onward, an environment for efficient problem setting and solving.

Although common in both river corridor management cases investigated, this deficiency particularly affected the Eisack/Isarco River Corridor Management process in Brixen/Bressanone ('StadtLandFluss'). Within the considered project duration, no feasible solutions could be found for the complex problems in a markedly urban environment and the participatory process proposed in Figure 2 could have addressed this. At the end of the project, it was necessary to start a tendering process for a competition of ideas for feasible design solutions, since these solutions did not fully emerge earlier in the process and no process iterations were foreseen to redefine the underlying developmental vision and re-engineer the associated knowledge requirements.

Lessons learnt with respect to problem (a):

As emerged from the structured interviews, the effects of this deficiency could have been mitigated by a coherent application of the first three steps of the participatory decision-making process (including [1] diagnosis; [2] vision and objectives for the river corridor; [3] decision space (options, strategies, alternatives); Figure 2). In fact, once successfully initiated, the management process has to guarantee, based on an accurate diagnosis and a rigorous portrayal of the developmental vision, that the elaborated

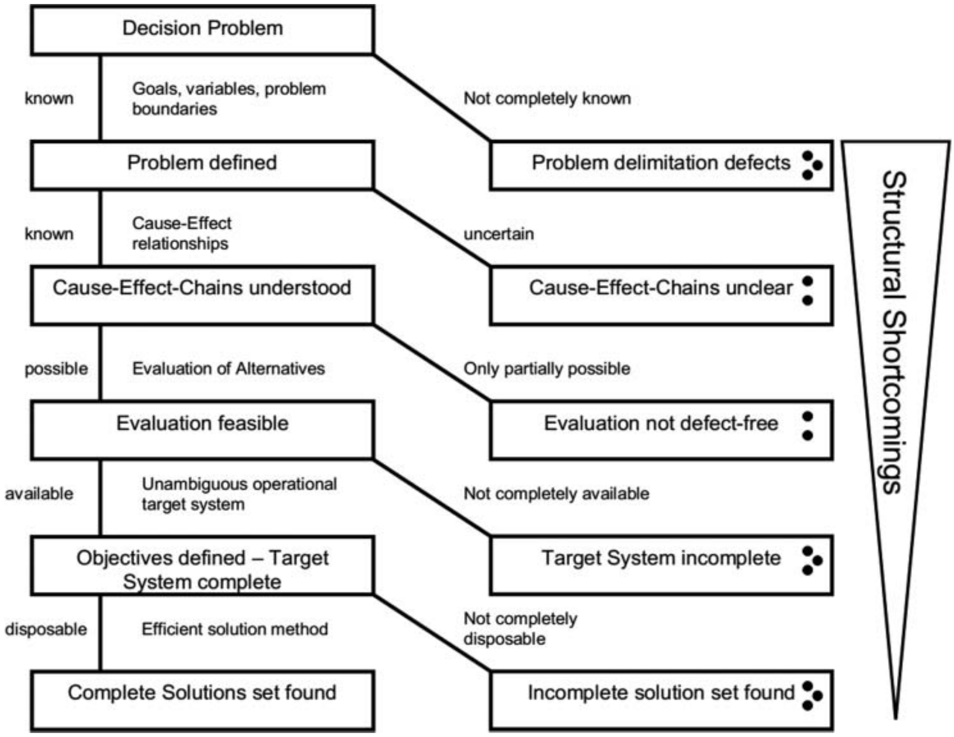

Figure 6. Structural shortcomings of the decision problems emerged both analysed river corridor management cases; crucial shortcomings detected in both cases; procedural shortcomings detected in both cases.

solutions fully reflect the developmental possibilities in the light of existing constraints. Better anchoring the vision (or Leitbild) would have prevented initial planning efforts that did not address all objectives initially defined by the stakeholders involved.

(b) Inaccurate delimitation and characterization of the river corridors past evolutions and present states and neglecting to account for its potential evolutionary trajectories.

Because, in both cases, the river corridors were not delimited and characterized according to the rivers' hydro-morphological and ecological characteristics, no consistent evolutionary trajectories with respect to both time and space could be deduced and taken into account in the subsequent planning efforts. Moreover, the prevailing focus was on flood hazard mitigation without sufficiently accounting for the full spectrum of possible objectives. This further constrained the solution space and the opportunity for a systematic search for multifunctional solutions was missed.

Lessons learnt with respect to problem (b):

In general, a hydro-morphologically based spatial delimitation of the river corridors and a deeper understanding of the river corridors past evolutions, present states, and potential evolutionary trajectories would have provided the rationale to prioritize the feasible restoration objectives. Particularly in the 'Etsch-dialog' initiative, a hydro-morphologically based planning approach would have considered both the reactivation of the paleo-channels (compare Figure 5[a] where a paleo-channel remains disconnected from the main channel) and flood risk mitigation targets. In the specific cases, the two objectives are not contradictory. In such a riverine setting, bolstering flooding processes to the benefit of aquatic and riparian habitats would be a feasible management option. In the Eisack/Isarco river corridor management process, the feasibility of multifunctional solutions in the urbanized areas is much lower than in the previous case. Nonetheless a proper extension of the river corridor study area both upstream and downstream of the urbanized river corridor would have provided opportunities to restore degraded river segments and to increase the functionality of the river through separating in space the prevailing focus of the available management alternatives. In such a case, working to re-initiate flooding processes in order to re-connect rivers and their floodplains to enhance aquatic and riparian habitats would have been possible in upstream river segments.

(c) Partial incongruence between projects and co-produced river corridor development scenarios.

The partial inability to compare the consistency between development scenarios and project initiatives resulted in significant drawbacks in both case studies. Projects that only partially reflect the envisioned river corridor lead to diminished trust, which risks undermining the prospects of success of existing and future initiatives.

Lessons learnt with respect to problem (c):

Transparency and consistency of the decision-making process in a participatory environment are essential to the success of a management process. The application of the proposed consistency matrix (compare Figure 2) and in particular of the proposed CA (compare Figure 3 and Appendix 1 [online supplemental data]) could have enhanced the envisioning, evaluation and decision-making phases. The proposed CA would have supported, from the early process stages onwards, both decision-makers and planners to move forward in a retraceable and accountable way. With a more explicitly defined operational target, for example, projects can more readily check whether the management decisions reflect the envisioned river corridor and engage in an iterative process of revision if necessary.

(d) Long-term strategic difficulty to stimulate the legislator to adapt the legal framework and remove obstacles for the integrated river corridor management process.

This shortcoming affected both initiatives to a similar extent due to the existing legal framework. River corridors need to be better rooted as a convenient planning unit within existing legal frameworks. This would entail benefits for ongoing and future river corridor management processes. The road toward the adoption of the approaches proposed in this paper might not be free of obstacles.

Lessons learnt with respect to problem (d):

Environmental and spatial planning agencies, accustomed to act in defined sectoral domains, may be initially reluctant to embrace an interdisciplinary way of working. The existing legal frameworks have to be modified and adapted by explicitly considering the river corridor as a spatial planning domain and by promoting collaborative and interdisciplinary planning among different spatial planning agencies. Also the planning guidelines, which are currently too domain specific, should be adapted and consider a sufficiently broad set of planning objectives. In the long term, the introduction of river governance is desirable, since every new project is potentially comprehensively assessed from a river corridor centred perspective. In such a way, the early detection of potential benefits or negative impacts related to a new project would be possible and the subsequent process steps more manageable.

4. Conclusions

In this paper, we proposed a methodology for applying a participatory process to enhance effective river corridor management. We discussed the participatory decision-making process and structured it into seven distinct steps, introducing a consistency matrix, which allows tracing all decision relevant knowledge and information throughout the participatory decision-making process. Through the proposed innovative elements for an enhanced river corridor management, we aim to achieve a better coherence between the desires of the society concerned, the river's natural evolution patterns and what is allowed within the existing legal framework.

In the light of the proposed participatory process, our two case studies highlight a set of requirements to enhance river corridor management processes, including: (1) unambiguous spatial referencing of the river corridor management process; (2) enhanced investigation quality of the river corridor's hydro-morphological and ecological footprints and related dynamics; (3) thorough understanding and representation of the main interactions taking place at the intersection between the river corridor-related hydro-, litho- and antroposphere; (4) transparency and consistency of the decision-making process in a participatory environment and clearly defined goals; (5) coherent alignment of the identified management options with the declared target systems and the existing legal framework. The innovative elements for river corridor management discussed in Section 2 address each one of these essential requirements both from a methodological and procedural perspective. However, to be truly effective, a strong will to apply a participatory and transdisciplinary approach across sectoral and institutional boundaries is necessary for long term success of the initiated participatory processes. Additionally, it has to be remarked that without a revision of the legal framework to incorporate the notion of the scientifically based river corridor concept – and its use as the most suitable management unit – the ambitious goal of restoring ecosystem functions, while also mitigating riverine processes such as flooding, will be difficult to attain. However, as suggested in this work, an enhanced and carefully structured participatory decision-making process for river corridor management is required to stimulate a constant dialogue between different management and governance levels that may eventually trigger the necessary institutional innovations and adaptations to the legal framework.

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Supplemental data

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